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On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

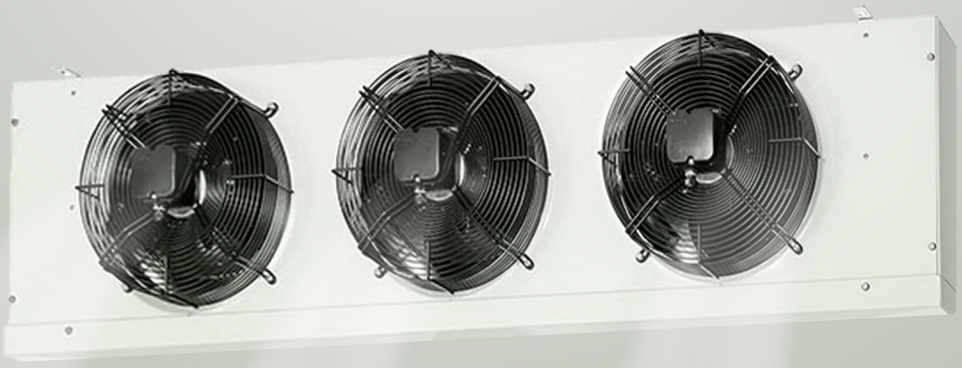
of the Federal Republic of Germany

CCL Cold Chain Logistics Resource Centre

CII Confederation of Indian Industry

Technical Specifications for

RIPENING CHAMBERS



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Developed under CCLRC

Cold Chain Logistics Resource Centre

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Cold Chain Logistics
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About Us

Cold Chain Logistics Resource Center

Cold Chain Logistics Resource Center (CCLRC) has been set up as an industry-led Center towards supporting and catalyzing the development of integrated cold chain networks across the country. The Centre is aligned with the overall objectives of reducing food loss, maximizing energy efficiency, and optimizing time and cost in the cold chain networks. The CCLRC vision is also dovetailed with the National Logistics Policy with key objective of integrated development of the logistics sector, leveraging multimodal transport, digital transformation, sector modernization, logistics excellence and democratization.

The key focus of the Center is aligned towards bringing in investment into the sector, supporting harmonization & convergence of Government's financial outlay for the sector, promoting Environmentally Sustainable Technology Solutions and Innovative Cross-functional Shared Infrastructure and enabling capacity building.

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About Us

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

As a service provider in the field of international cooperation for sustainable development and international education work, we are dedicated to shaping a future worth living around the world. The 2030 Agenda is the overarching framework that guides our work. For over 60 years, GIZ has been working jointly with partners in India for sustainable economic, ecological, and social development. The Federal Ministry for Economic Cooperation and Development (BMZ), the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU) as well as the Federal Ministry for Economic Affairs and Energy (BMWi) are the main commissioning parties of GIZ in India.

The Government of India has launched numerous important initiatives to address the country's economic, environmental, and social challenges, and GIZ is contributing to some of the most significant ones. For example, it supports key initiatives such as Smart Cities, Clean India and Skill India. GIZ, in close cooperation with Indian partners, devises tailor-made, jointly developed solutions to meet local needs and achieve sustainable and inclusive development.

Confederation of Indian Industry

About Us

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government, and civil society through working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for Industry.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. The premier business association has over 9000 members, from the private as well as public sectors, and an indirect membership of over 300,000 enterprises from around 294 national and regional sectoral industry bodies.

With 62 offices, including 10 Centres of Excellence in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian Industry and the international business community.

Confederation of Indian Industry

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Acknowledgment

The Cold Chain Logistics Resource Centre (CCLRC) works with a vision to support and catalyze the development of integrated cold chain networks across the country. Towards the same, a series of technical reference manuals have been developed for most used cold chain infrastructure— including cold stores, ripening chambers and reefer vehicles, which are available as open source (at WWW.CCLRC.in) to be utilized by new entrants of the industry.

We would like to thank and acknowledge the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH for their support towards developing this document series.

We would also like to acknowledge our international technical experts from United Nations Environment Programme (UNEP) and Alliance for Energy Efficiency (AEEE); and industry experts from Blue Star, Carrier Transicold and Desai AgriFoods, without whose support, efforts and invaluable inputs, this document would not have been possible.

Objective

The objective of this document is to provide a standard in basic design selection of Room sizes depending upon the space availability, loading pattern and refrigeration capacity for 5MT, 10MT & 15MT ripening chambers and to impart knowledge for the buyers.

What Is Ripening?

Usually fruits produce ethylene gas, a plant hormone, naturally that ripens the fruits. It changes the fruit's composition from starch to sugar

Artificial ripening is done to achieve faster and more uniform ripening characteristics. In General, artificial ripening is done by unsaturated hydrocarbons line Acetylene, Ethylene. However, Acetylene is not nearly as effective for ripening as is Ethylene and acetylene is not a natural hormone as ethylene.

Exposure of unripe fruit to a very small dose of ethylene is sufficient to stimulate the natural ripening process until the fruit itself starts producing ethylene for its ripening.

- **Climatic Fruits:** After harvest they continue to ripen off the tree/plant. Some climatic fruits are Mango, Banana, Papaya, Guava, Sapota, Kiwi, Fig, Apple, Passion fruit, Apricot, Plum, Pear.

- **Non-Climatic Fruits:** After harvest they do not ripen further. Some Non-climatic fruits are Orange, Mousambi, Kinnow, Grapefruit, Grapes, Pomegranate, Litchi, Watermelon, Cherry, Rasberry, Blackberry, Starberry.

Types of Ripening

Calcium carbide (Cac2) Ripening:

When calcium carbide reacts with water it produces acetylene gas (Popularly referred as Carbide gas) which is an analogue to Ethylene and quickens the ripening process. Calcium carbide is a strong reactive chemical which has carcinogenic properties & is used in gas welding. Earlier calcium carbide was used for ripening and **this was banned in India by FSSAI in 2011 & also by many other countries due to the health hazards of the below.**

Health Hazards of calcium carbide

- Farm produce Contains traces of Arsenic & Phosphorous hydride.
- Could cause Cancer, Neurological disorders like Tingling sensation, numbness, periphernal neurology.
- If consumed pregnant, children could be born with abnormalities.
- For those who handles it will have short term effects like Headache, dizziness, mood disturbances, sleepiness, mental confusion, seizures.
- For those who handles it will have long term effects like Memory loss, seizure, prolonged hypoxia, cerebral oedema.
- Fruits ripened with calcium carbide are overly soft and inferior in taste(tasteless) & flavor and have a shorter shelf life. Calcium carbide may develop a strong attractive colour, but the tissue inside would not be ripe or may remain green or raw.
- Artificial ripening by use of calcium carbide was generally practiced for Fruits & vegetables like Mango, Banana, Papaya and sometimes for sapota (Chiku), dates & Tomatoes.

Ethylene Ripening:

Ethylene is the only safe & scientific method used for ripening by all countries. Ethylene can be induced into the ripening chamber by using a portable Ethylene generator or by a cylinder containing mixture 5% of Ethylene gas and Nitrogen or by pure ethylene with automated controls.

- Portable Ethylene Generators (Manual process): This is a small rectangle tank with one liter volume holding capacity & heater. The heater heats the catalytic liquid/Fluid by around 400 ° C (supplied by the manufacturer) which is filled in the rectangle tank and ethylene is generated instantly/simultaneously. The main advantage of portable Ethylene generator over a Pressurized cylinder is low rate of ethylene production over a time around 500ppm (0.05%). Generally, 300ml of liquid is used for 150m3 of ripening room volume (Slightly differs from Manufacturer to Manufacturer). The rate of Ethylene generated is 0.5m3 for 10 Hrs (0.5m3/10Hrs) and the fluid consumption is one Litre for 10 Hrs (1L/10 Hrs).

- Automatic Ethylene Injectors: This system uses programmed controller to supply the Ethylene gas (C2H4) from cylinders with timers, Ethylene sensors, Co2 Sensors, Dampers, solenoid valves, Room temperature & Pulp temperature sensors

Geometry Of Ripening Chambers

A near cubical size room should be considered for a ripening chamber for maximum efficiency, since the amount of Heat leakage is directly proportional to the exposed outside surface area.

The figures and table below provide a comparison of cubical volume to outer surface area. Fot the rectangular shaped chamber (Fig 3) the cost of insulation & cooling to make good the leakage will be greater 18.83% with respect to cubical cold room.

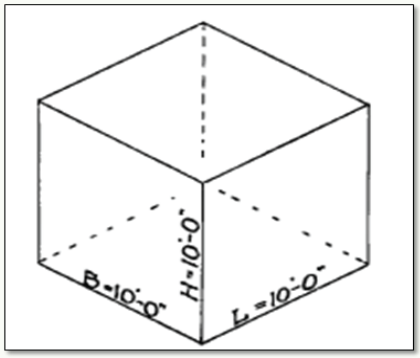


Fig-1

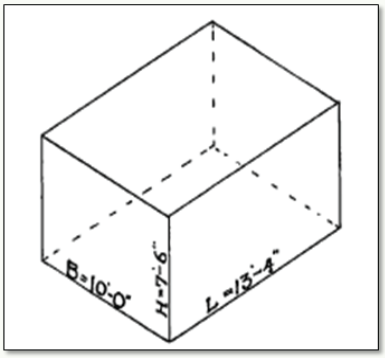


Fig-2

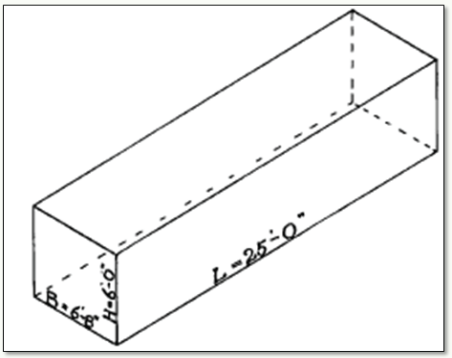


Fig-3

Reference Figure	Cubical Volume in Cubic feet	Outside surface area exposed (Sq ft)	% of Cubic ft Volume/ Exposed Surface Area (Sq ft.)	% of increased surface area over cube surface area
Fig-1	1000	600	60	1
Fig-2	1000	616	61.6	2.67
Fig-3	1000	713	71.3	18.83

Therefore, a cube nearer may be approximated, the cheaper the first cost and cost of operation.

For Goods of long storage, a house of several floors is practically convenient, cost is less, is cheaper to operate and requires less ground space.

General Composition Of Ripening Chambers

- Minimum of 4 Ripening chambers will be needed for continuous operation (i.e. unloading for fresh banana for ripening & loading of ripened banana for market).
- Ripening chambers are mostly utilised for Bananas. The recommended density of loading is 150 to 200kg of Bananas per cubic meter of the volume of the ripening.
- 30% Free volume of total cold room volume has to be provided for air circulation
- The thickness of PUF insulation shall be 80mm thick with a density of 38 to 40 Kg/m3.
- 50mm thick PUF slabs for flooring & 100mm thick civil/kota flooring.
- The tar felt (Asphaltic Roofing roll) on bottom & top of 50mm PUF slab shall be of 1mm thick or 20kg/roll.
- The clear door opening shall be 1 x 2.0 Mtr for swing door and 1.3x 2.1 Mtr, 2.4x2.1 Mtr for sliding door or space depended
- Plastic perforated pallet shall be of size 1x1.2 Mtr or 1.016x1.219 Mtr.
- Normally used perforated plastic crate sizes are 510 x 330 x 310mm (LxWxH), 540 x 360 x 275mm (LxWxH) and 600 x 400 x 250 (LxWxH)
- General stacking height is 7 to 8 crates, where each crate has a capacity from 16 to 21 KG/crate.
- A minimum of 100mm space/gap is required between pallets for proper air circulation.
- The internal height of the ripening chamber shall be 3 Mtr.

Fixed Storage Capacity with Different Dimension Of Ripening Chamber Size

Different Options of Ripening Chamber Size - Depending upon the Space Availability

Room Capacity	Option-1 size LxDxH mm	Option-2 size LxDxH mm	Option-3 size LxDxH mm	4 Rooms Combined size LxDxH mm
5 MT	3708 x 4153 x 3230	4218 x 3747 x 3230	2898 x 4863 x 3230	11354 x 4863 x 3230
10 MT	4713 x 5737 x 3230	5273 x 4924 x 3230	4824 x 547 x 3230	20850 x 4924 x 3230
15 MT	4824 x 6792 x 3230	5537 x 5979 x 3230	5940 x 5473 x 3230	23520 x 5473 x 3230

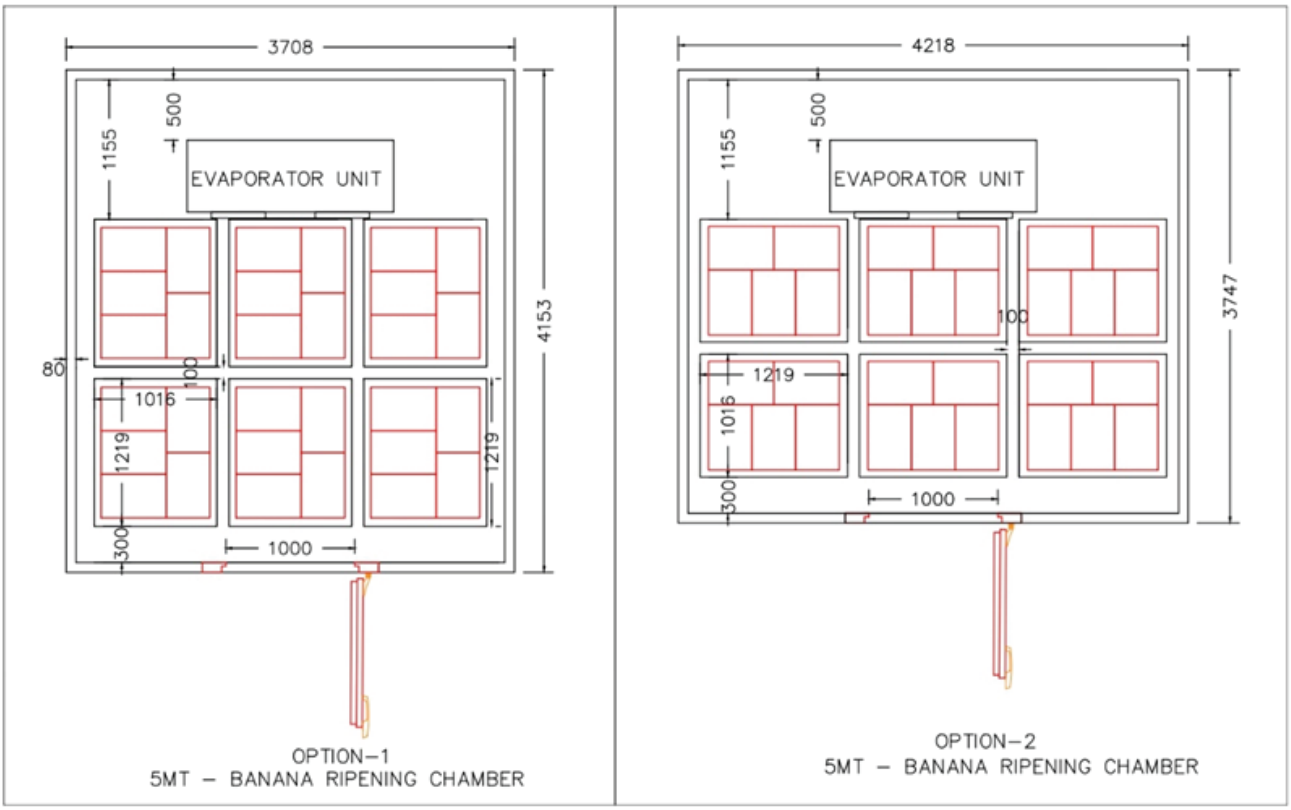
(Reference - NIL: Calculated one)

Required Refrigeration capacity & Power consumption of Ripening Chamber:

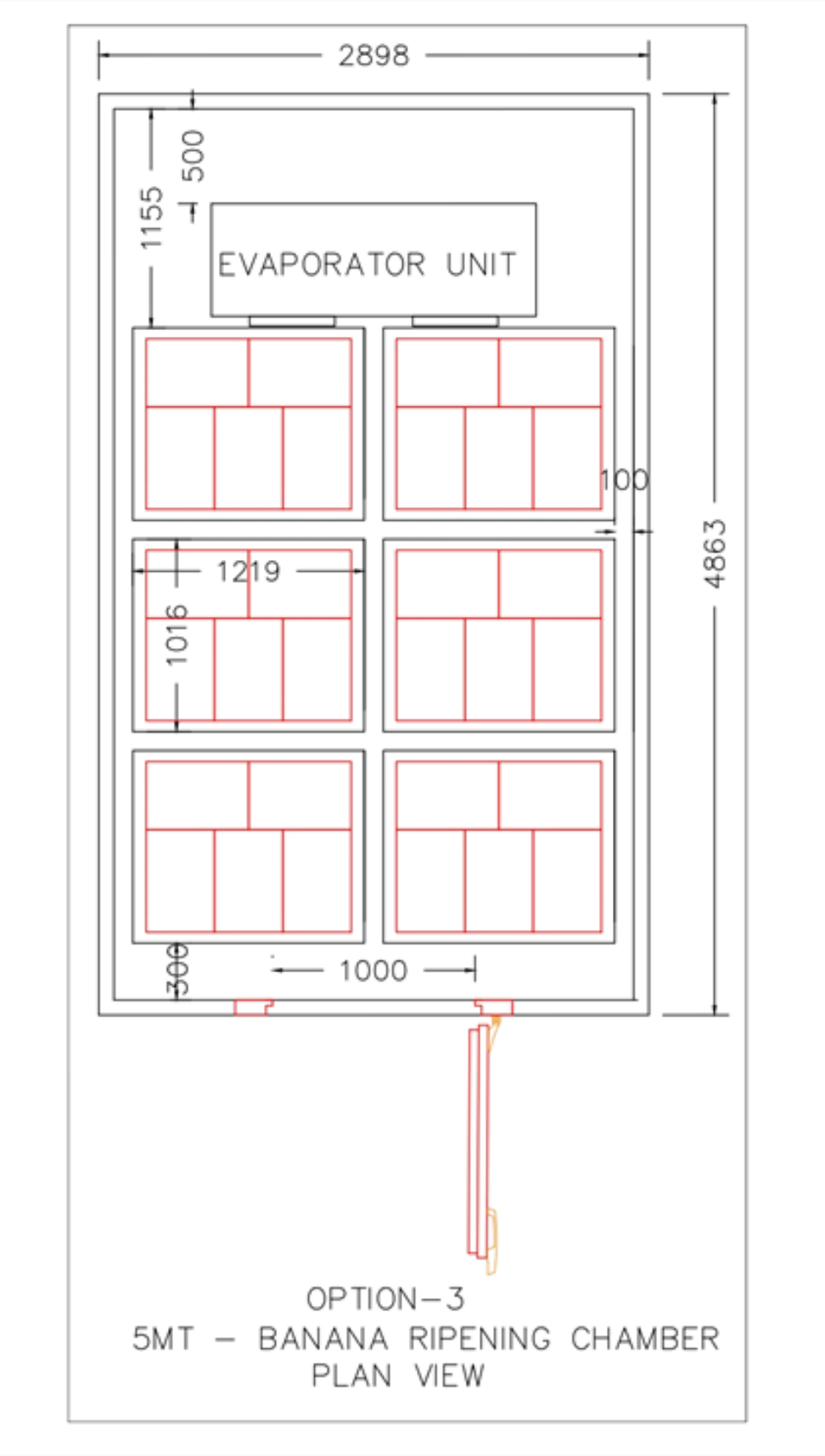
Room Capacity	Refrigeration capacity- BTU/Hr (KW/Hr)	QTY (Numbers)	Power input per unit -KW	Power input per chamber - KW(R404A)
5 MT	30,000 (8.8)	1	4.4	4.4
10 MT	30,000 (8.8)	2	4.4	8.8
15 MT	40,000 (11.72)	2	6.24	12.48

(Reference - NIL: Calculated one)

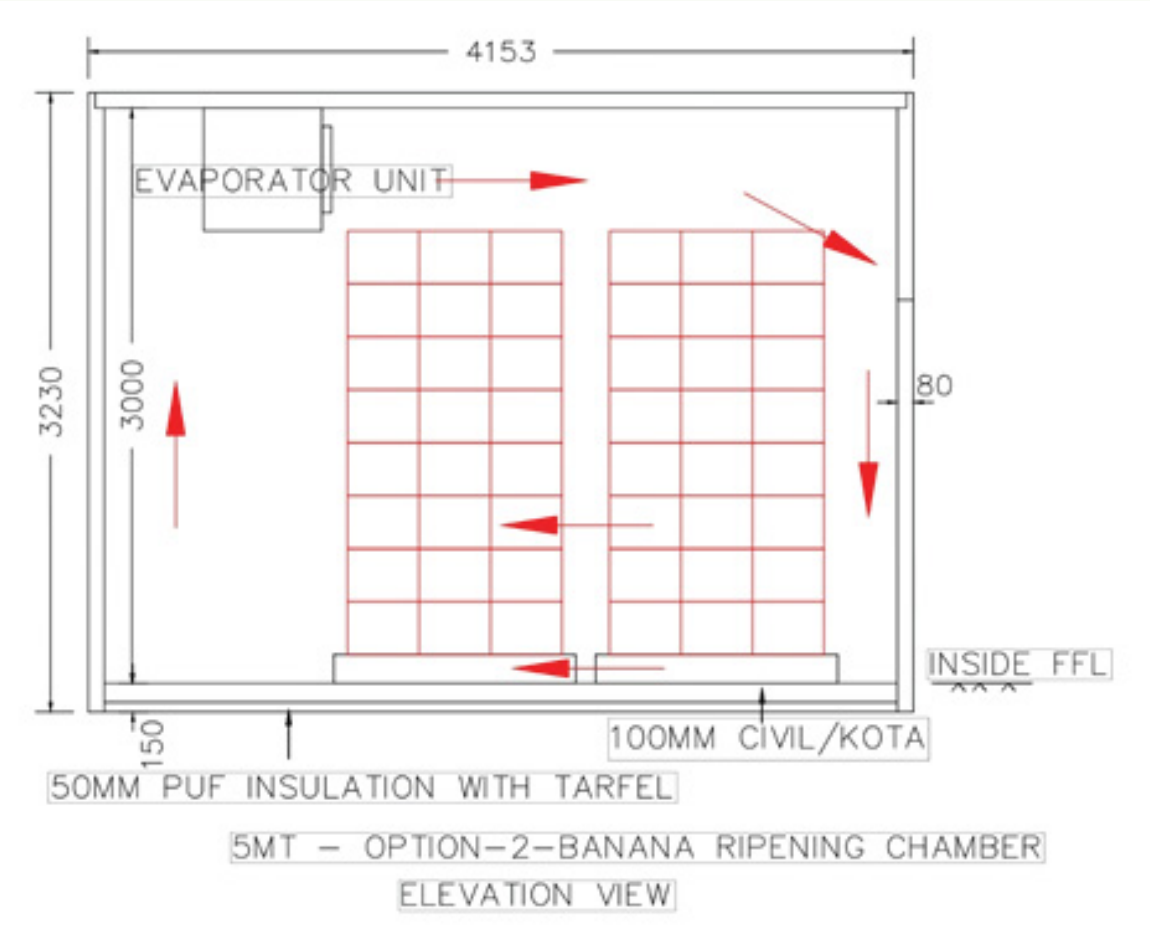
5MT Ripening Chamber - Three Types Pallet Stacking Method & Room Sizes Type-1 & 2 Layout:



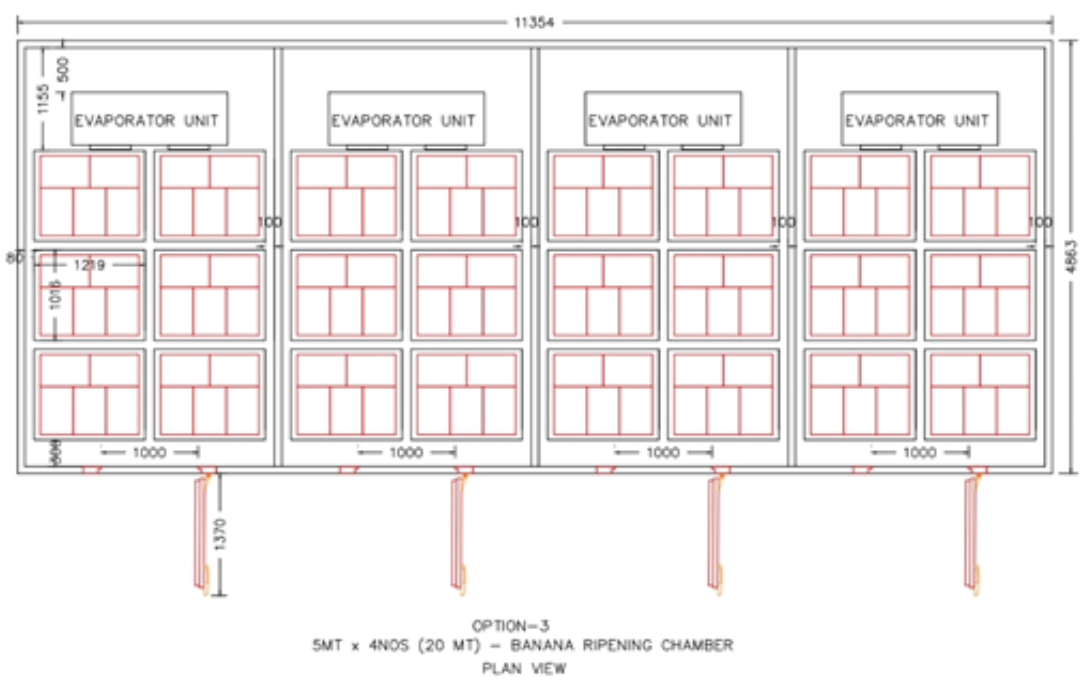
Type-3 Layout:



5MT- Ripening Chamber Elevation

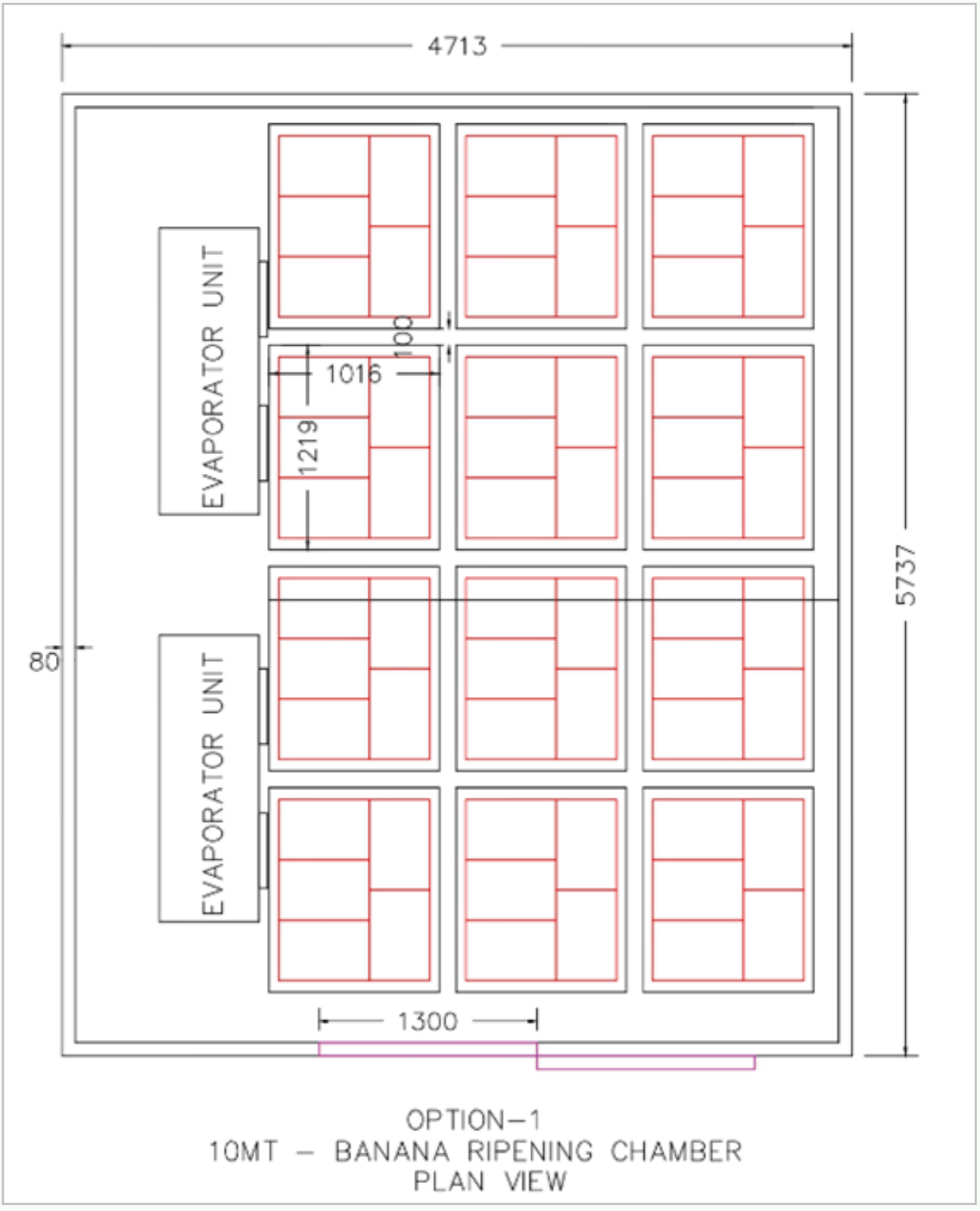


5MT X 4Nos (20MT) Ripening Chamber for 24x7 Hrs continuous operation

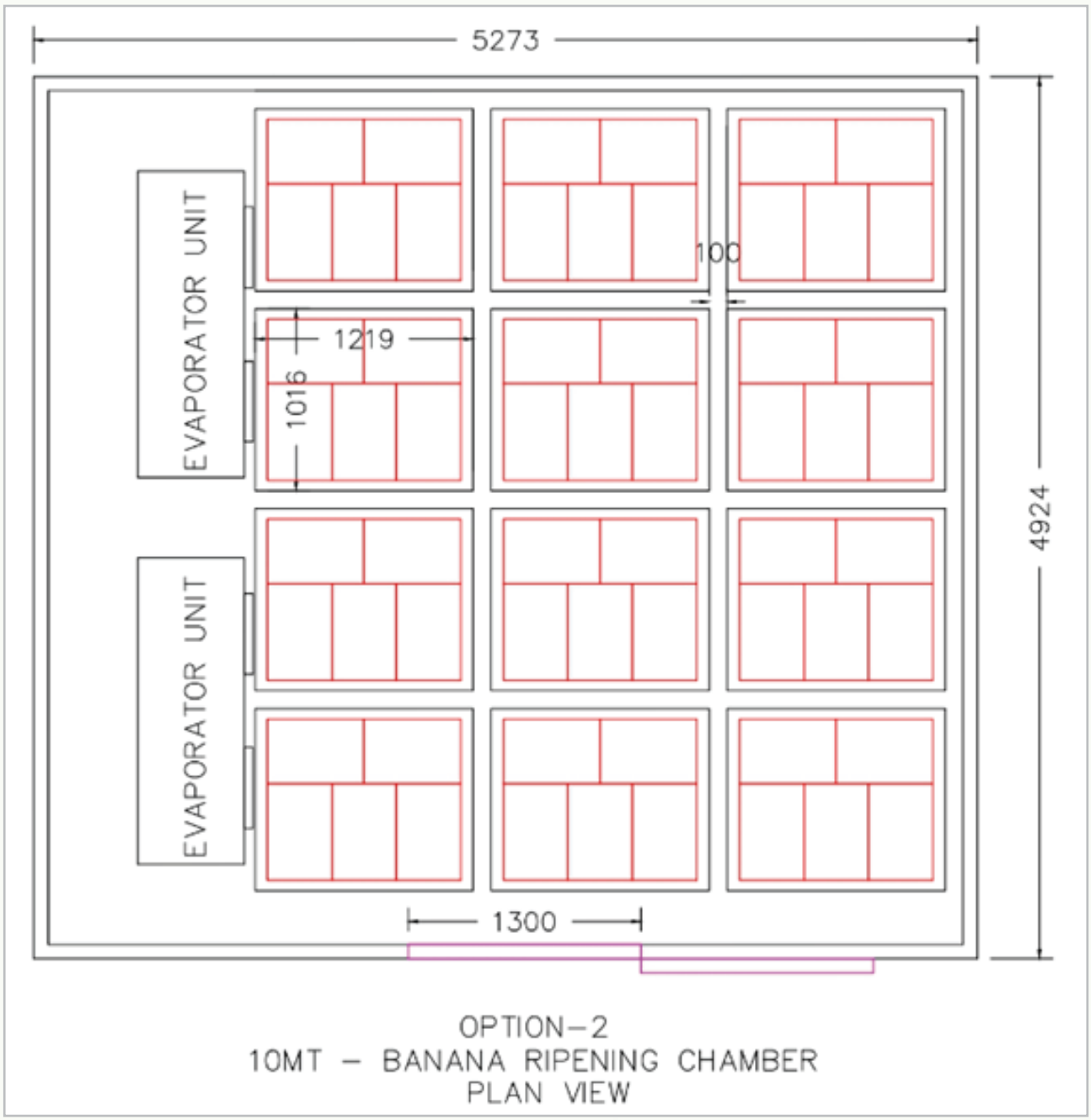


10 MT Ripening Chamber -Three Types Pallet Stacking Method & Room Sizes

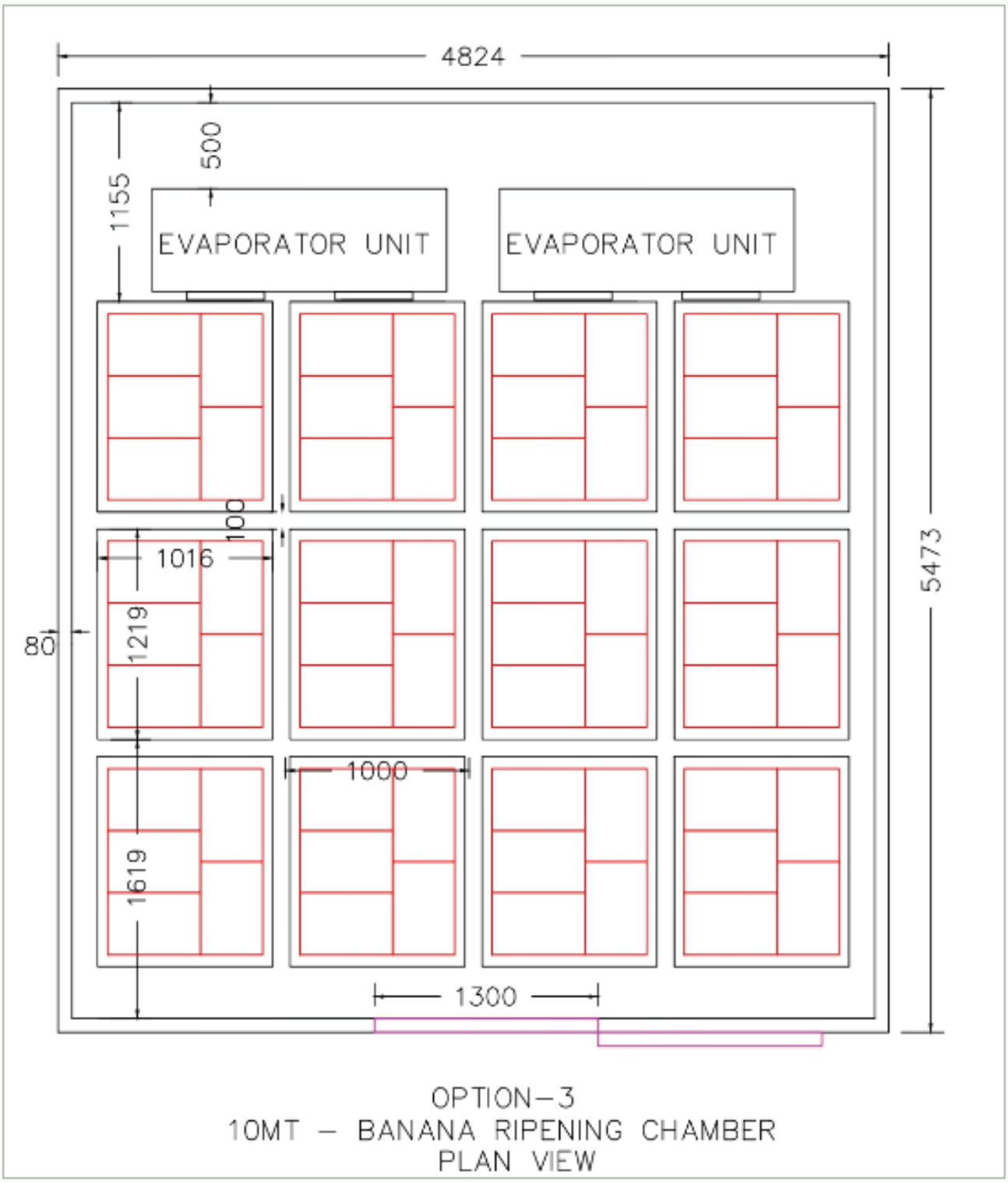
Type-1 Layout



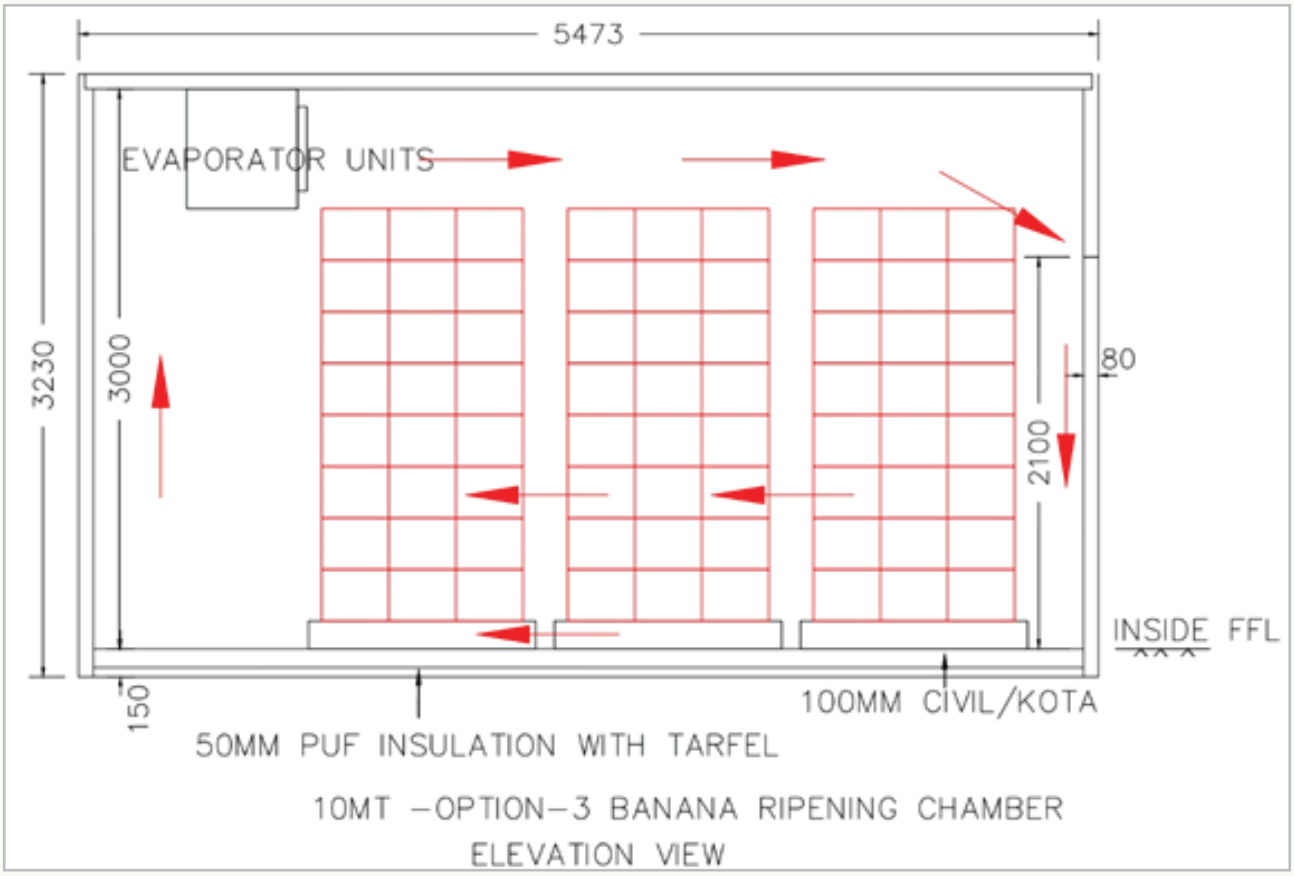
Type-2 Layout



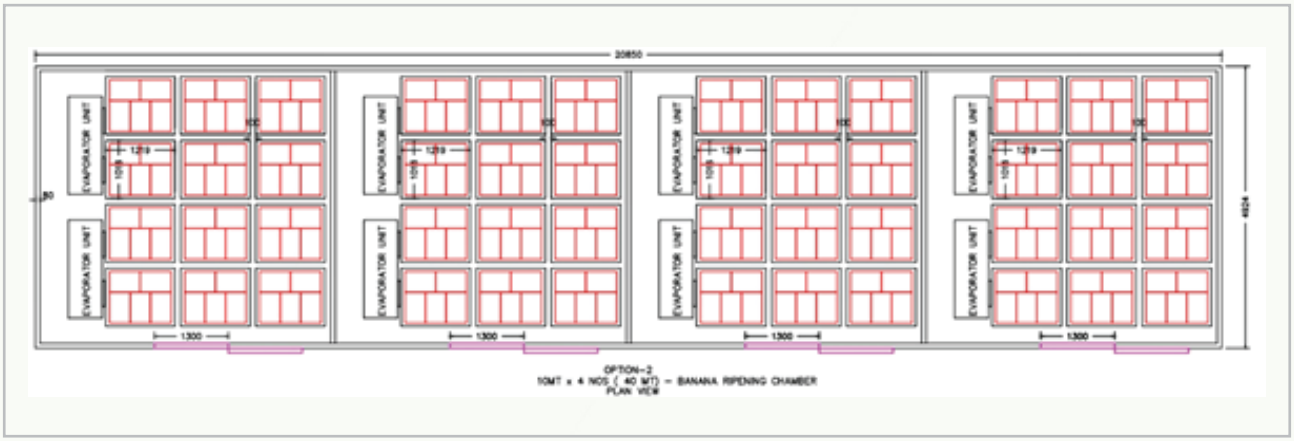
Type-3 Layout



10MT- Ripening Chamber Elevation

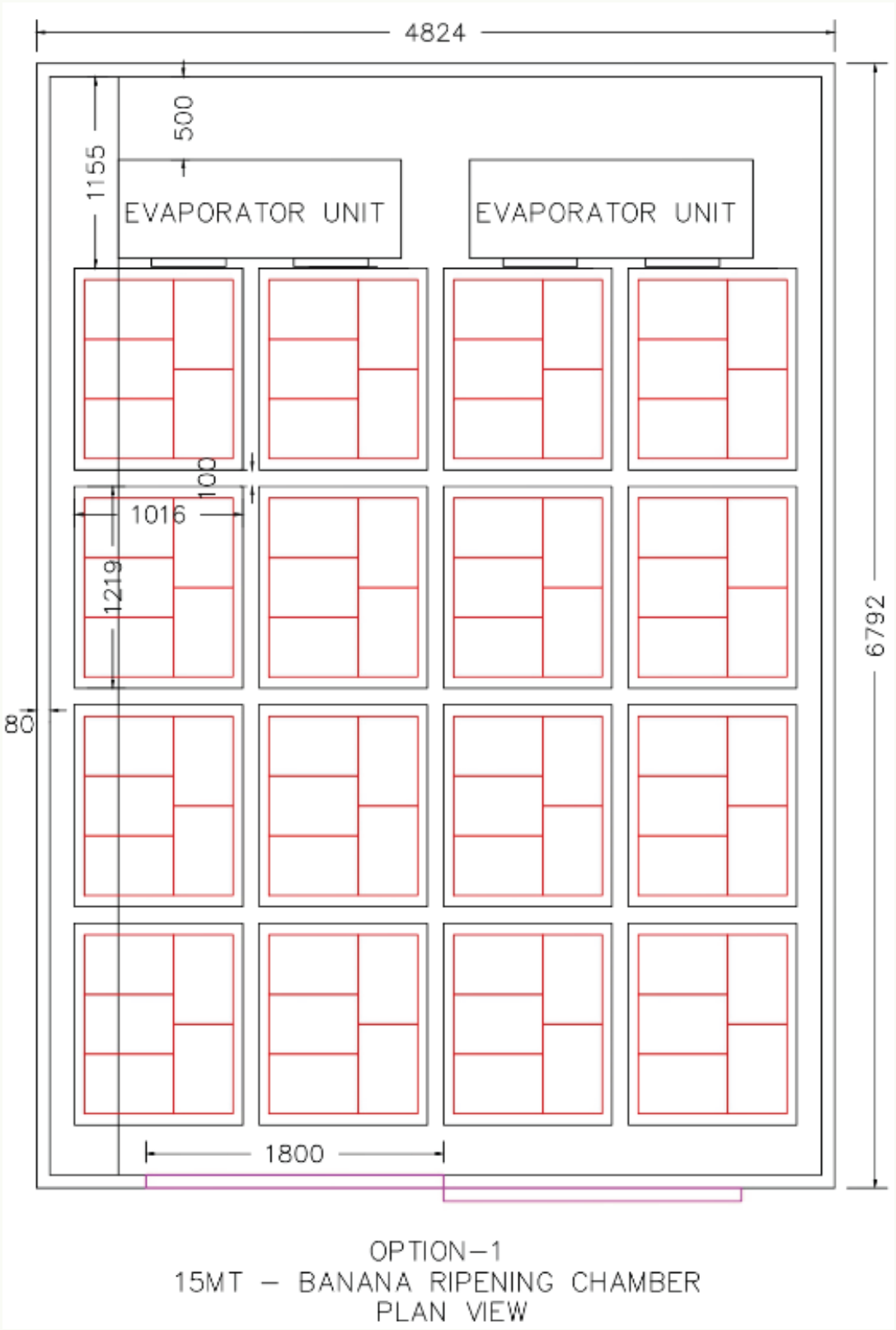


10MT X 4Nos (40MT) Ripening Chamber for 24x7 Hrs continuos operation

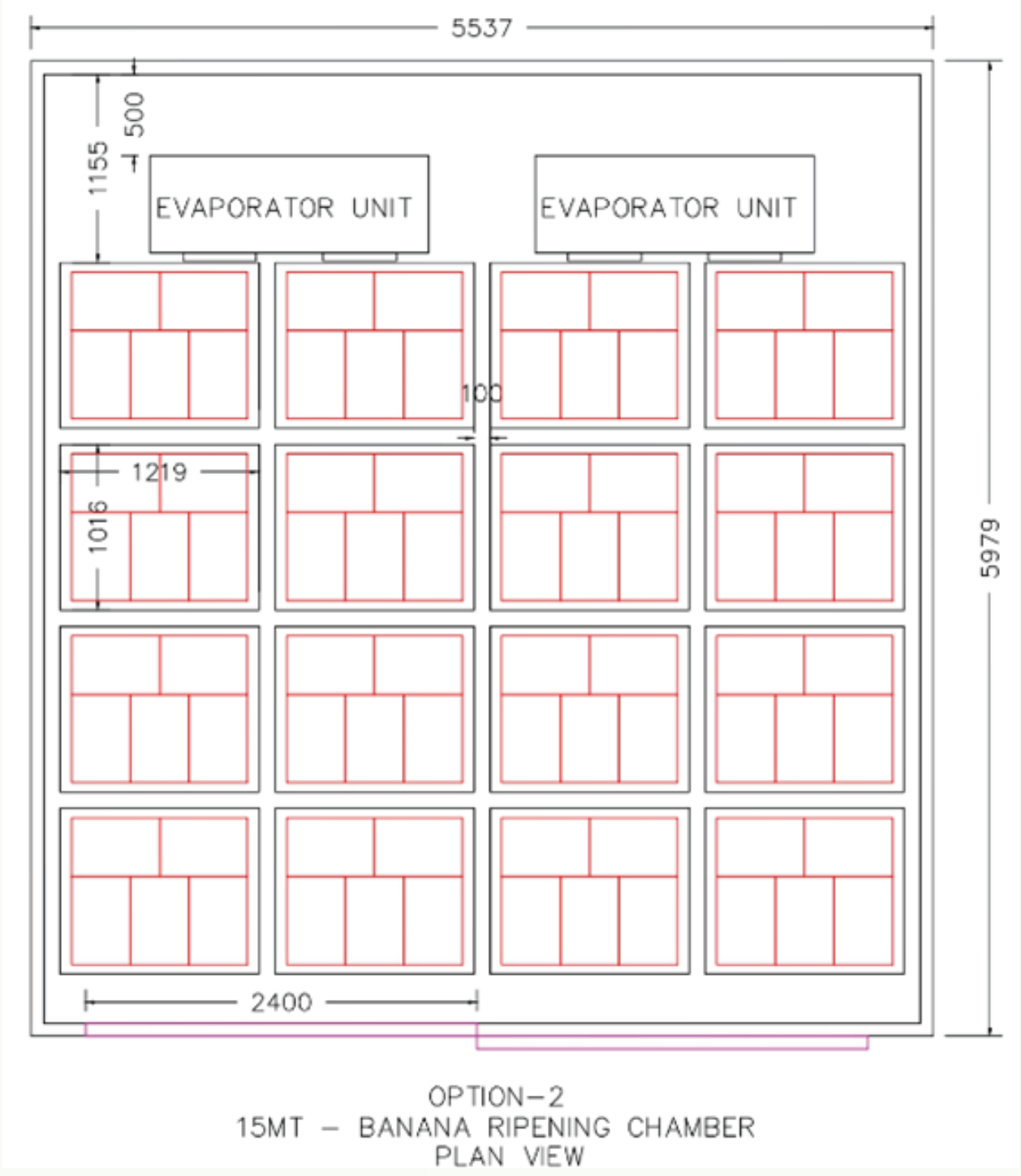


15 MT Ripening Chamber -THREE TYPES PALLET STACKING METHOD & ROOM SIZES

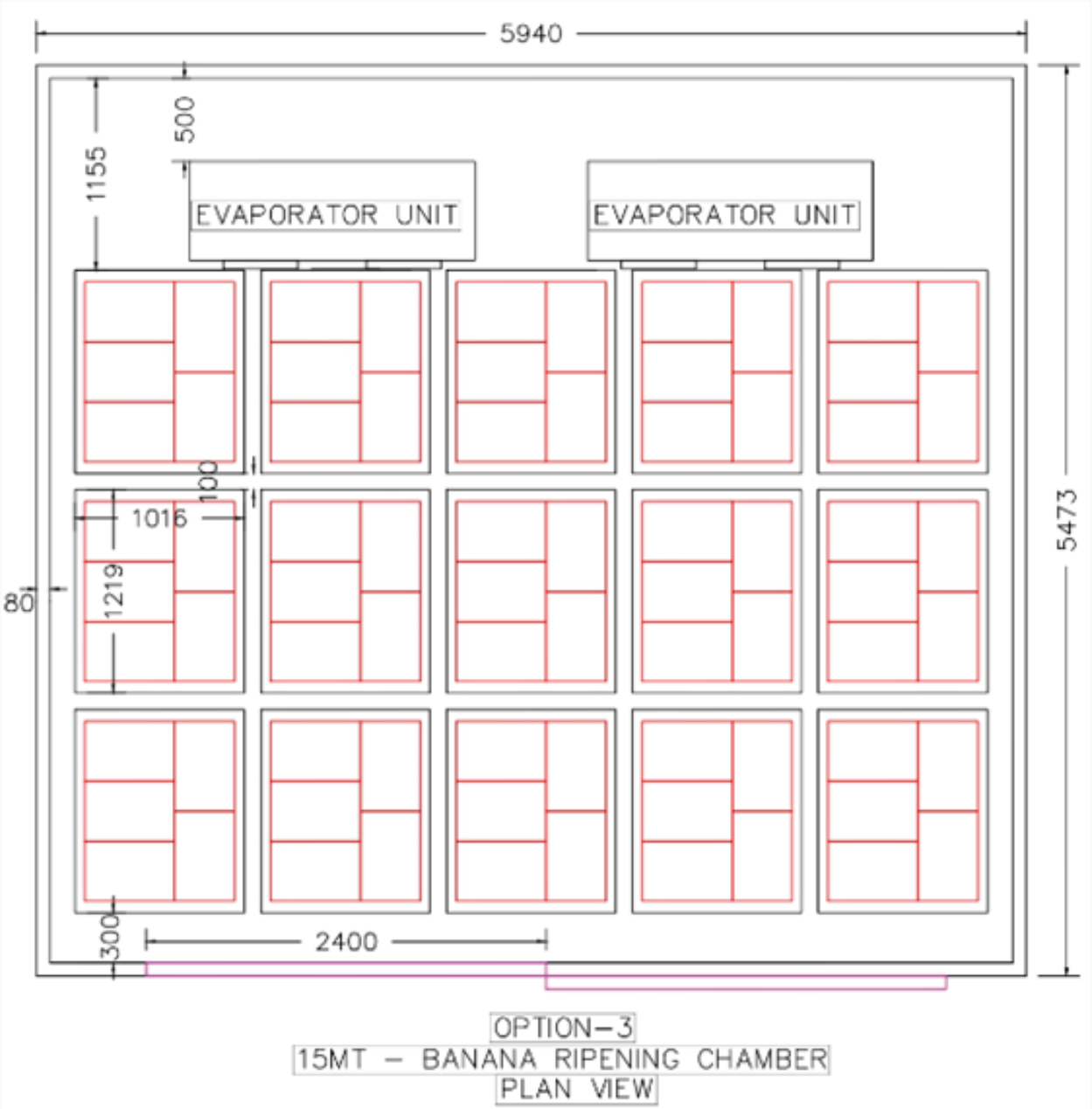
Type-1 Layout



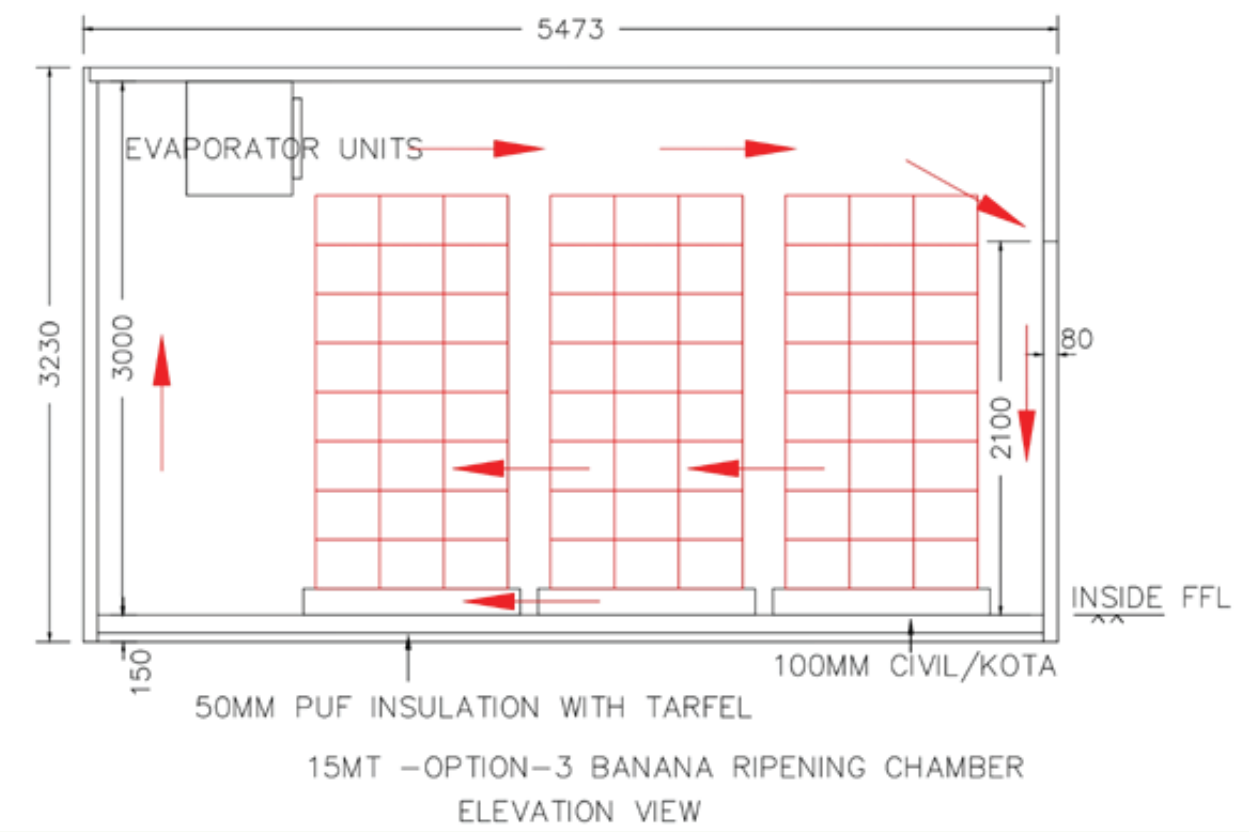
Type-2 Layout



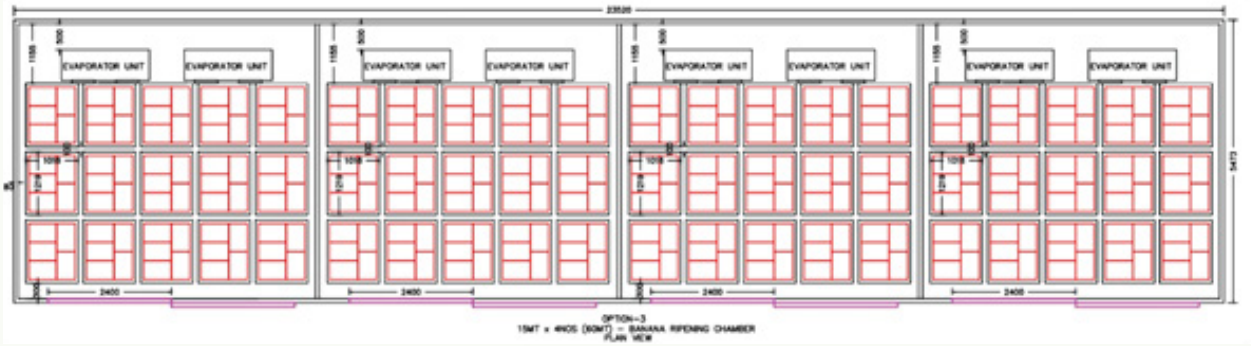
Type-3 Layout



15MT- Cold Room Elevation



15MT X 4Nos (60MT) Ripening Chamber for 24x7 Hrs continuous operation



Refrigeration Unit Design Selection[1]

- The cold room refrigeration capacity shall be arrived at Refrigerant temperature of 4.4 ° C & -3.8 ° C SST.
- Air temperatures used during processing range from 18.33 ° C to 7.2 ° C.

Tentative Budgetary cost of 5MT, 10MT & 15MT Ripening Chambers

S. No.	Ripening Room Description	Supply & Installation Basic Cost. Rs.
1	5MT (Single Cold Room)-Manual Ripening	655,000
2	10MT (Single Cold Room)-Manual Ripening	10,50,000
3	15MT (Single Cold Room)-Manual Ripening	11.85.000
4	5MTx 4nos (20MT- Cold Room) - Automatic Ripening System	25,75,000
5	10MTx 4nos (40MT- Cold Room) -Automatic Ripening System	39,95,000
6	15MTx 4nos (60MT- Cold Room) - Automatic Ripening System	45,00,000

The below main components (Supply & Installation) are included in the above costing.

- Cold room PUF panel & Kota civil flooring
- Cold room Refrigeration units
- Doors
- Tube lights
- Ethylene Generator
- Humidifier.
- Electrical control panel for Refrigeration units.
- Outdoor unit MS Stand.

[1] Reference: 2018 ASHRE Handbook – Refrigeration – Chapter 36

Thermal Properties of Products

	Moisture Content %	Initial Freezing Point ° C	Specific heat above freezing- KJ/(Kg.K)	Specific heat below freezing- KJ/(Kg.K)	Latent Heat of fusion- Kj/Kg	Heat of Respiration @20 ° C- (mW/Kg)	Normal Storage Temperature ° C	Relative Humidity - RH %	Approx. Storage Life
Banana	74.26	-0.8	3.56	2.03	248	242.5	12.7-18.3	85-90	-
Mango	81.71	-0.9	3.74	1.95	273	449.1	12.7	85-90	2-3 weeks
Papaya	88.3	-1.24	3.51	1.75	293.9	291	7.2	85-90	1-3 weeks
Pears	83.31	-1.6	3.08	2.06	280	266	-0.5-1.6	90-95	2-7 months
Tomato	93	-0.6	4.02	1.77	311	120.3	12.7 -21.1	95	1-3 weeks

(Reference: 2006 ASHRAE Handbook - Refrigeration - Chapter 9 and ASHRAE Applications Handbook 1964)

Ripening Temperature & Storage Temperature

Product	Ethylene concentration (PPM)	Ethylene Exposure (Hours)	Ripening Temperature ° C	Storage Temperature ° C
Banana	100-150	24	15 - 18	14
Mango	100	24	20 - 22	10 - 13
Papaya	100	24 - 48	20 - 25	About at 7
Pears	100 - 150	24 - 72	18 - 22	About at 0
Tomato	100-150	24 - 48 days	18 - 20	12.5

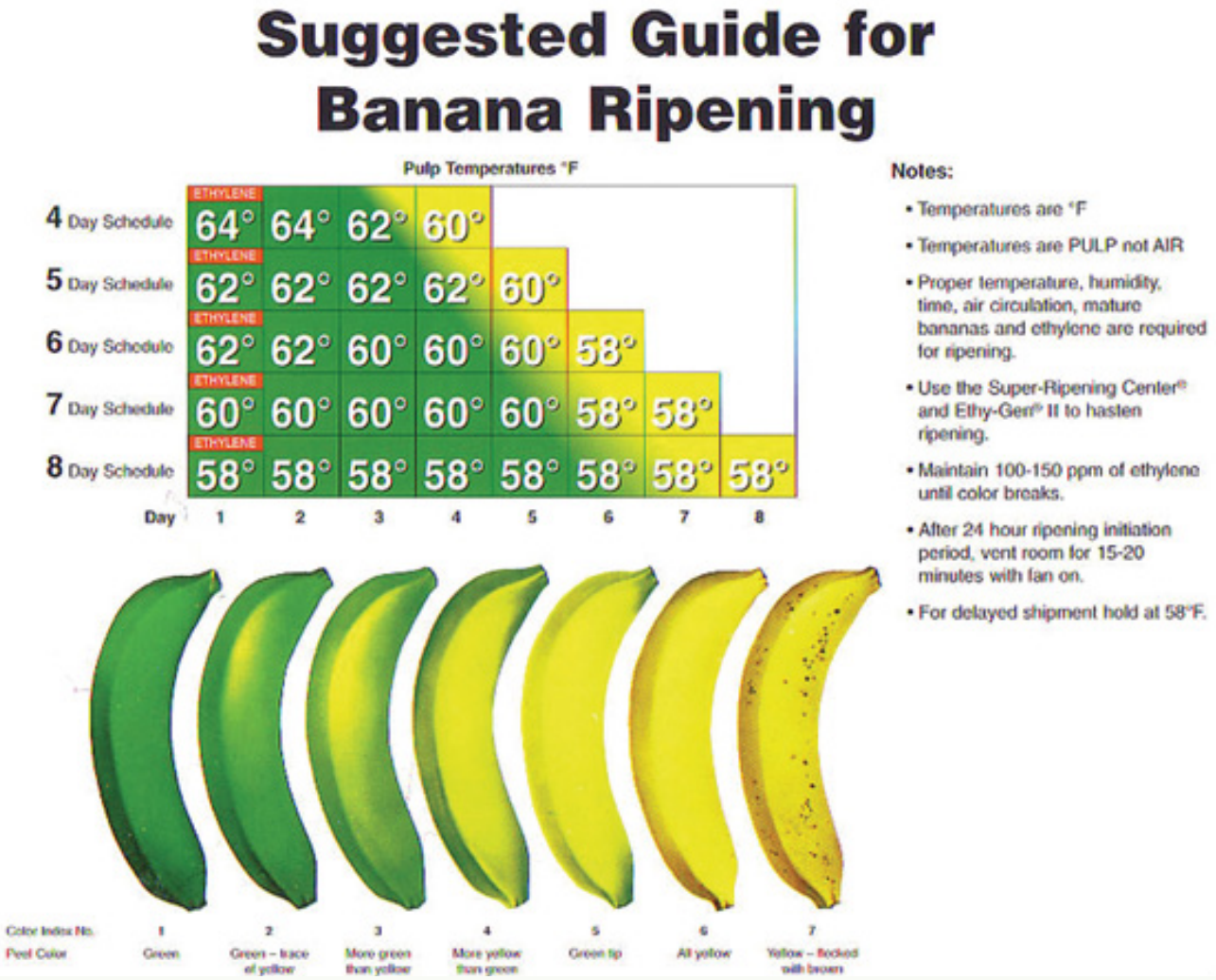
(Reference: NHB-CS-Type 04-2011- Technical standards and Protocol for fruit ripening chambers in India)

Annexure

BANANA RIPENING PROCESS-Details

1. Banana normally gets matured after 120 days of planting.
2. It is transported to cold room ripening chambers when they are 75 to 80% mature.
3. Transportation preferably to be done within 24hrs from farm by crates with leaves to avoid damage.
4. Bananas should be cleaned with clean water to remove stains, Latex and other dirt's.
5. After washing, Fungicide treatment is given by washing with 0.5% carbendazim water (1ml in 1 liter of water) for 10 to 20 seconds.
6. Washed bananas are placed in crates with pedicel facing upwards.
7. After residual water dripped out, it is weighed & moved into the ripening chamber.
8. Precooling of banana is done with 16 to 16.5 ° C pulp temperature within 4 to 5 hours. This is necessary for uniform ripening of bananas & avoid darkening of skin due to adverse temperature variation. Vent the room for 15 to 20 minutes for every 12 hrs. Increase the temperature to 18.5 - 19 ° C and keep for the first full day.
9. For best ripening, Humidity should be between 85 to 95%, A Humidifier shall be used if Humidity is low.
10. Ripening carried out in 2nd day- The pulp temperature is set at 18 ° C and ethylene dosing is either done by pure ethylene gas or N2 mixed ethylene or by portable ethylene generators for 24 Hrs. and Ethylene PPM is maintained at 100 PPM (to max 150 PPM depending upon the fruit).
11. After 24 Hrs of gassing/dosing, the room is vented out for 15 to 20 minutes by manual opening of door while the indoor fans are working for every 12 Hrs. or by use of automated exhaust/inlet fans to bring fresh air with Co2 sensors. This is required to remove the CO2 inside & increase the O2 for beathing of banana & to break down polysaccharides to monosaccharides.
12. After gassing, in 3rd day the temperature of pulp is reduced by 0.5 to 1 ° C every day and
13. Normally after 3.5 days green colour breaks & yellow shades appear, which shows that autocatalytic enzyme is activated and banana starts ripening.
14. In 4th day, the temperature is set at 16 to 16.5 ° C. The peel colour changes to yellow & is ready for dispatch.
15. The ripening is delayed by lowering the pulp temperature.

SUGGESTED BANANA RIPENING TEMPERATURE & DAYS



(Reference: Catalyticgenerators.com)

Banana can be ripened in 3-1/2 days to 8 days depending upon the demand requirement in the market.

Confederation of Indian Industry

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